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Stations at High Altitude for Research on the Environment

Short Lived Climate Forcers over Nepal Himalayas

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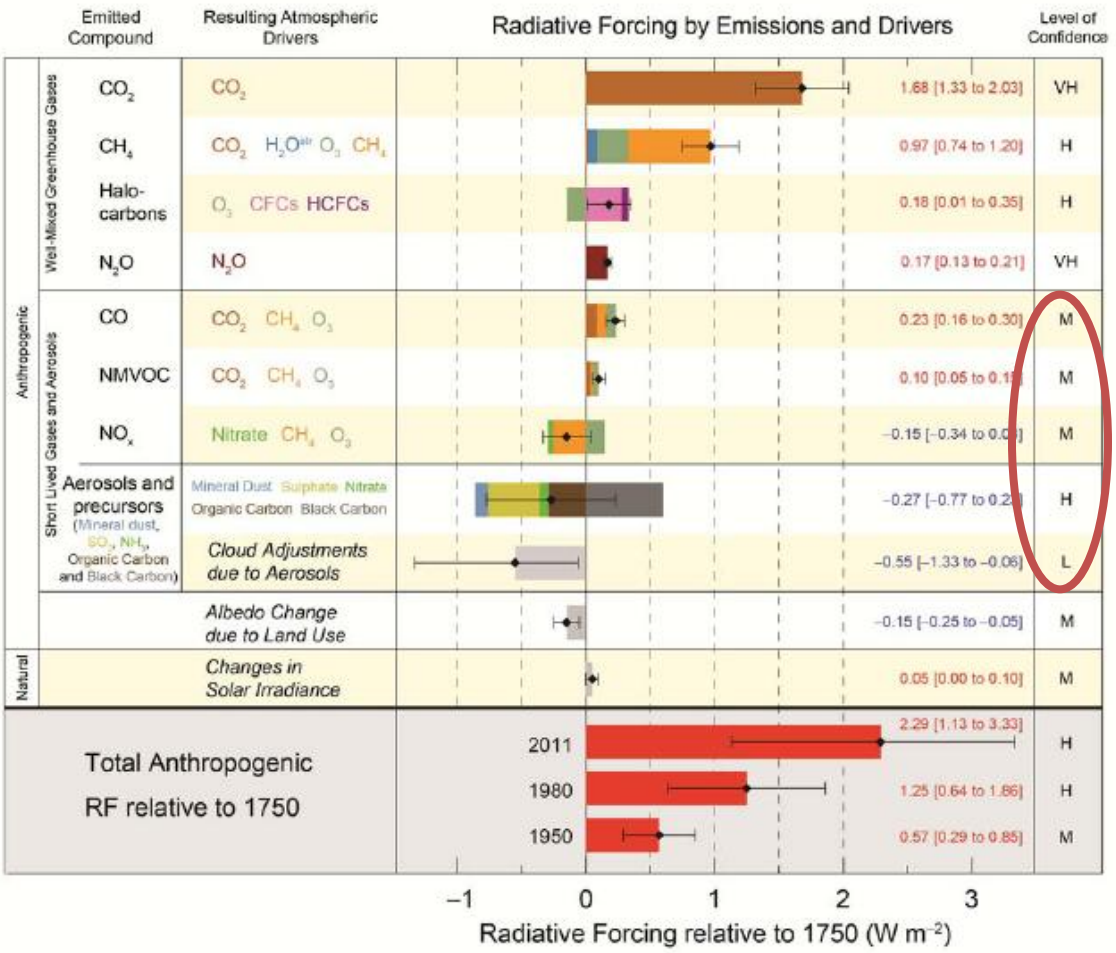
SHORT Lived Climate Forcers

Source: IPCC Summary to Policy Makers 2013

A **climate forcer** is any compound that perturbs the radiative budget of the earth.

- Greenhouse gases (GHGs) such as CO_2 and methane warm the earth/climate by trapping the outgoing radiation
- Atmospheric particles can either warm or cool the earth/climate based on their chemical composition. Soot particles warm the climate while sulfate particles cool the atmosphere
- Based on their atmospheric residence times, climate forcers are considered as **short lived such as ozone and black carbon** (atmospheric residence time of a few weeks to a month) compared to CO_2 and HFCs (atmospheric residence time of more than hundred years)
- **Short lived implies non uniform concentration through out the globe. Variation in concentration leads to regional changes in radiative balance**



Ozone and BC as the two important SLCFs

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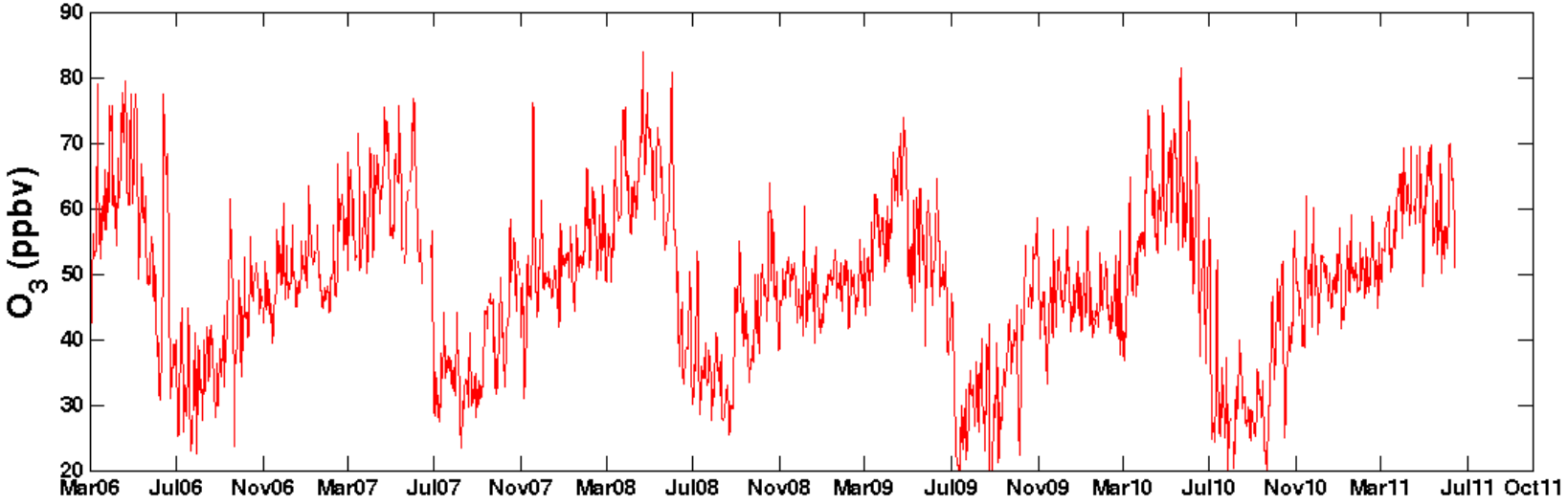
Pyramid International Laboratory

EvK2CNR in collaboration with Nepal Academy of Science and Technology (NAST) - Highest Ambient Measurement Station

Ozone Measurement



Clear seasonal cycle – Similar to BC cycle (shown later).

Cristofanelli et al. 2010 (ACP)

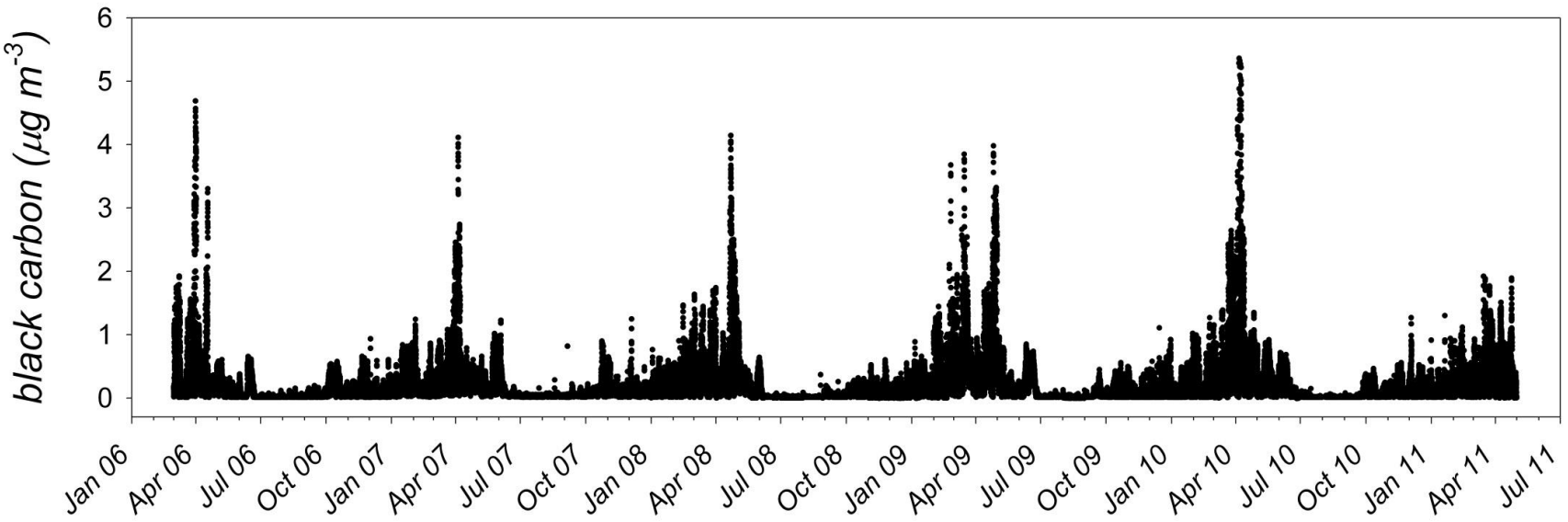
March 2006-Feb 2008: Avg Ozone was 49±12 ppbv.

Pre-monsoon 61±9 ppbv.

Stratospheric Intrusion (SI) events contribute to +13 ppb, 14.1 % days analyzed were found to be SI events

Cristofanelli, P., A. Bracci, M. Sprenger, A. Marinoni, U. Bonafè, F. Calzolari, R. Duchi, P. Laj, J.M. Pichon, F. Roccato, H. Venzac, E. Vuillermoz & P. Bonasoni. 2010. Tropospheric ozone variations at the Nepal Climate Observatory – Pyramid (Himalayas, 5079 m a.s.l.) and influence of stratospheric intrusion events. In: Special Issue "Atmospheric brown cloud in the Himalayas" *Atmospheric Chemistry and Physics*, 10: 5537-6549.

NCO-P BC Measurements



Seasonal Cycle

Peak during the pre-monsoon, ABC- high altitudes versus the IGP and South Asia

Maximum values of up to 5 ug/m^3

Year 2011 significantly lower than previous measurements

Marinoni, A., P. Cristofanelli, P. Laj, R. Duchi, F. Calzolari, S. Decesari, K. Sellegri, E. Vuillermoz, G. P. Verza, P. Villani & P. Bonasoni. 2010. Aerosol mass and black carbon concentrations, a two year record at NCO-P (5079 m, Southern Himalayas). In: Special Issue "Atmospheric Brown Clouds in the Himalayas" *Atmospheric Chemistry and Physics*, 10: 8551-8562.

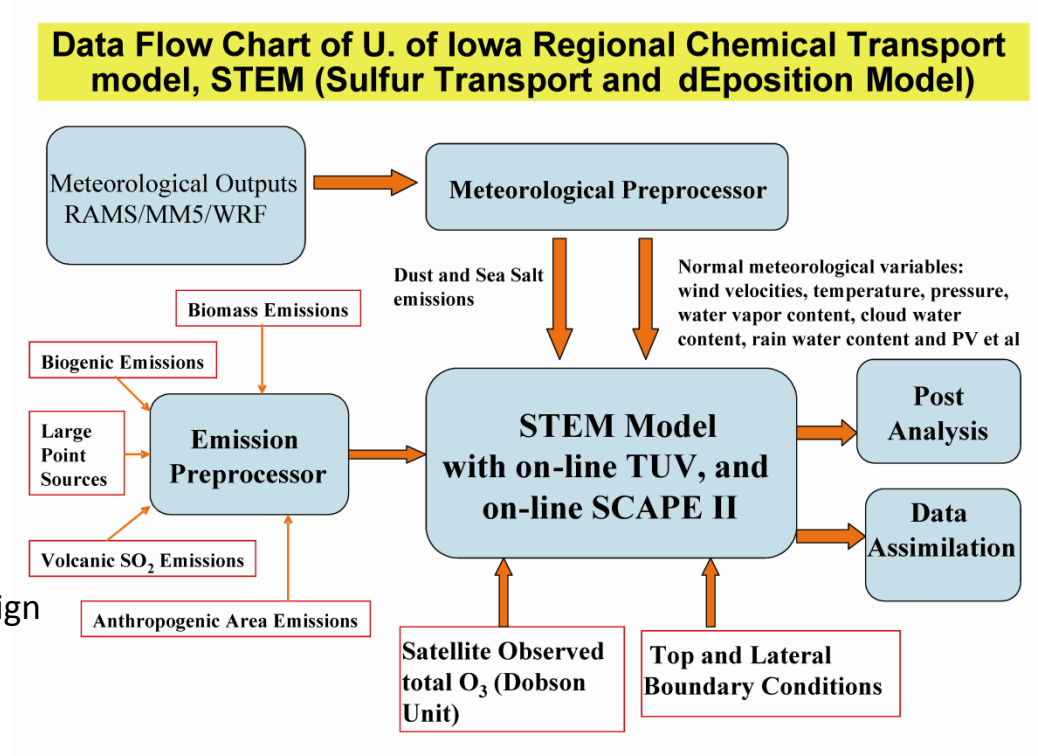
Regional Scale Modeling Perspectives

METEOROLOGY

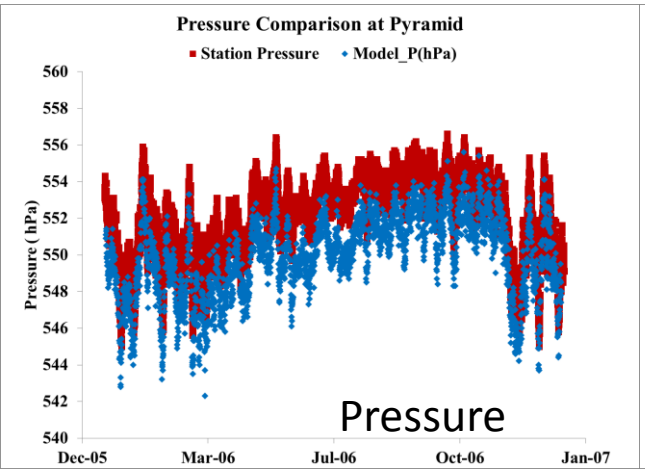
- WRF version 3.3.1
- NCEP –GFS Forecast/Reanalysis
- 3 Nested Domain, 54-18-6 km
- 2 Nested Domain 30-6 km
- Weather Simulations
  - Forecast Mode
  - Hindcast Mode

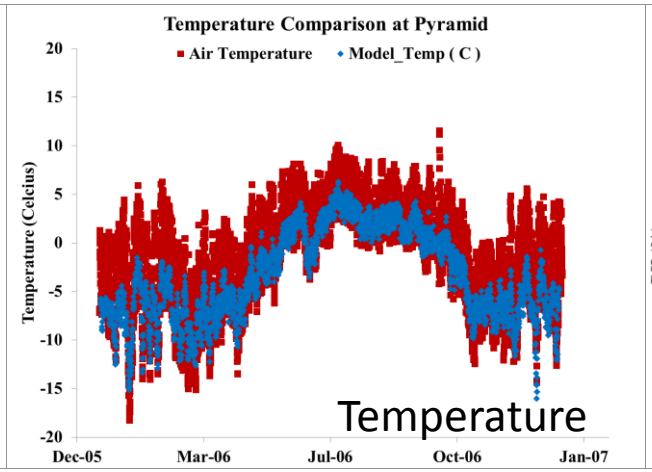
CHEMISTRY – STEM

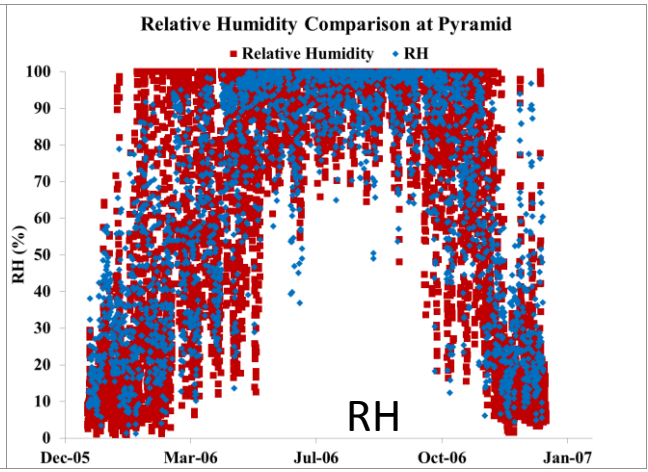
- TRACER version at 54x54 km
- Emissions Inventory – ARCTAS field Campaign
- Biomass Emissions – FINN model NCAR
- Fixed top and lateral BC
- 1 month spin up



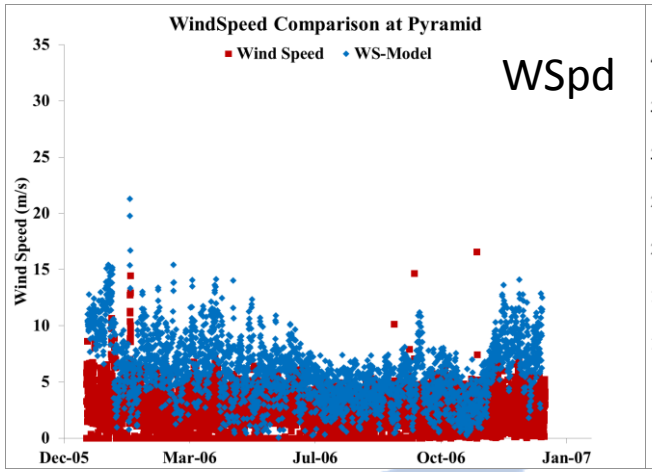
Model Assessment: Met Comparison- 54km

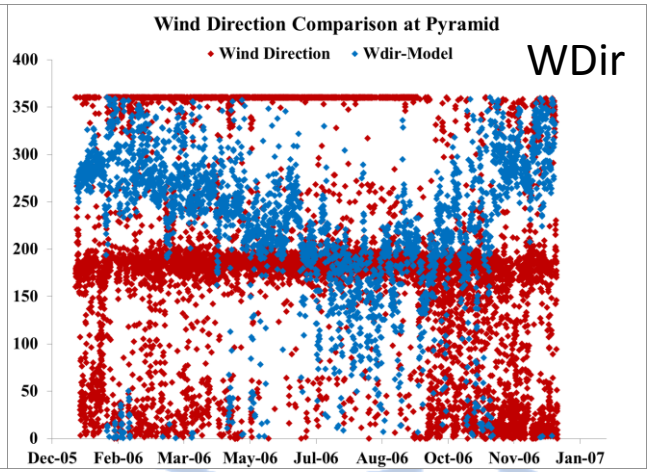






Model
Blue





Observation
Red

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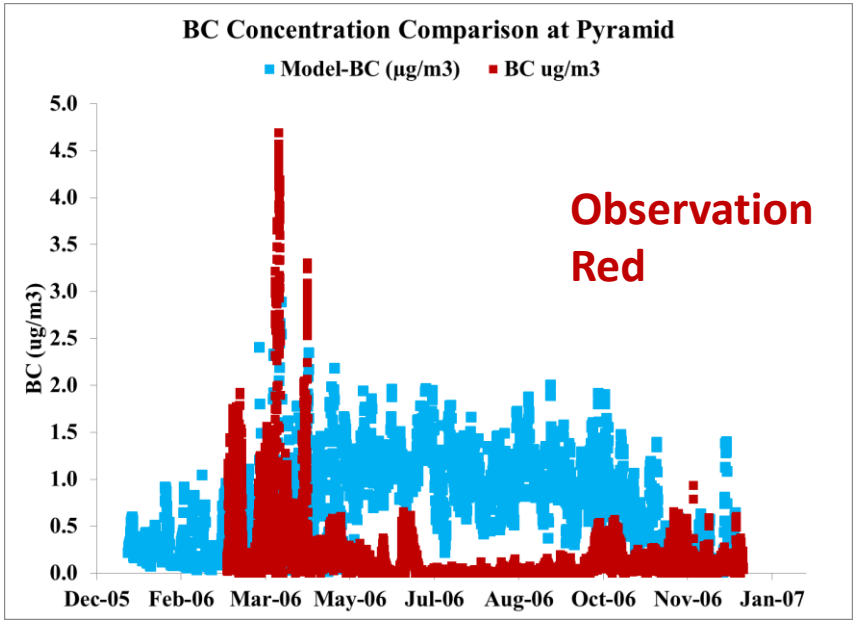
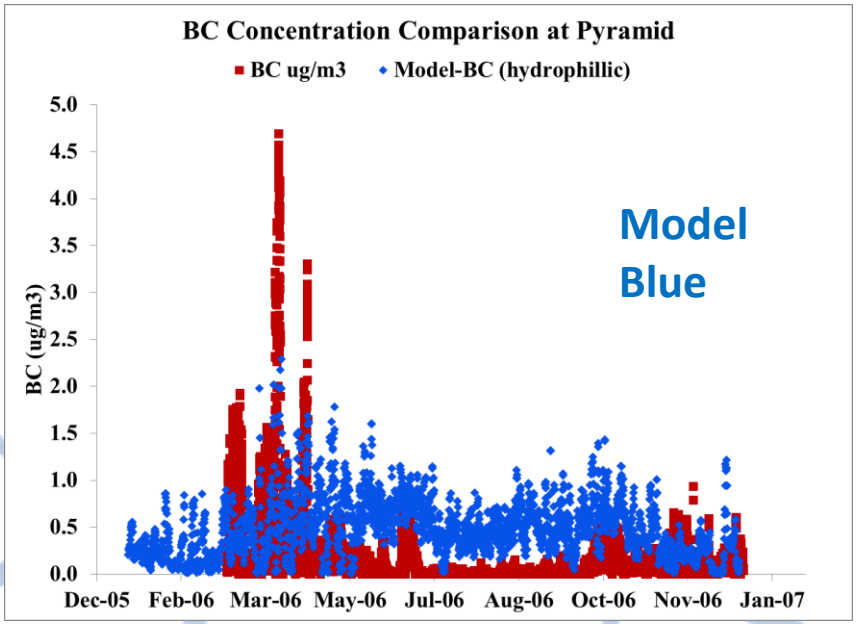
Chemical model
Preliminary assessment
NCO-P Pyramid

Black Carbon

- Over Prediction during monsoon months
- Annual BC Emissions
  - Only Biomass BC has seasonality
- Aging of BC, deposition processes
- May need to go higher resolution to avoid grid scale effects



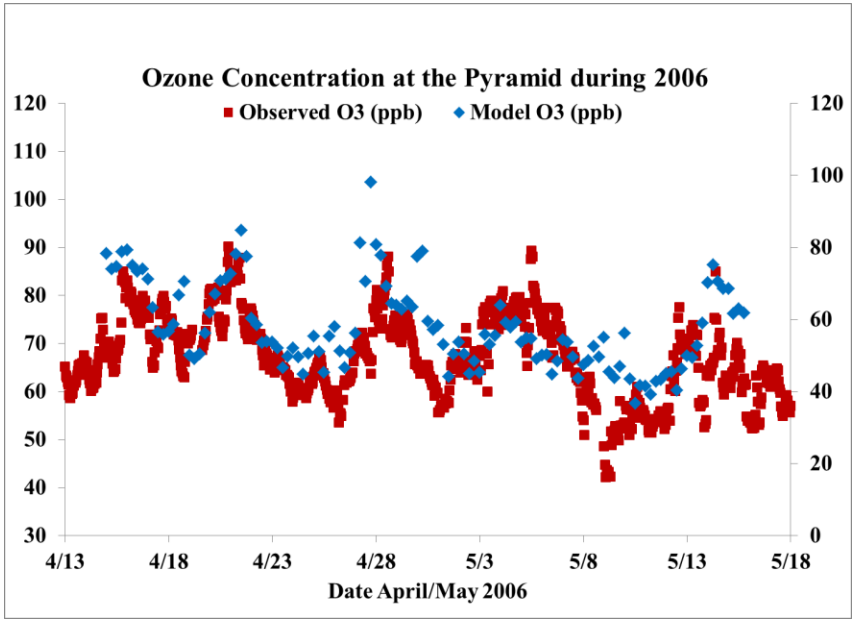


Chemical model Preliminary assessment NCO-P Pyramid

Ozone

- Slight under prediction
- Current state of regional emission inventory seem to be qualitatively correct however, modeling is restricted to just 1 month in 2006
- Higher resolution emissions for speciated VOCs not available

Observation Red



Model Blue

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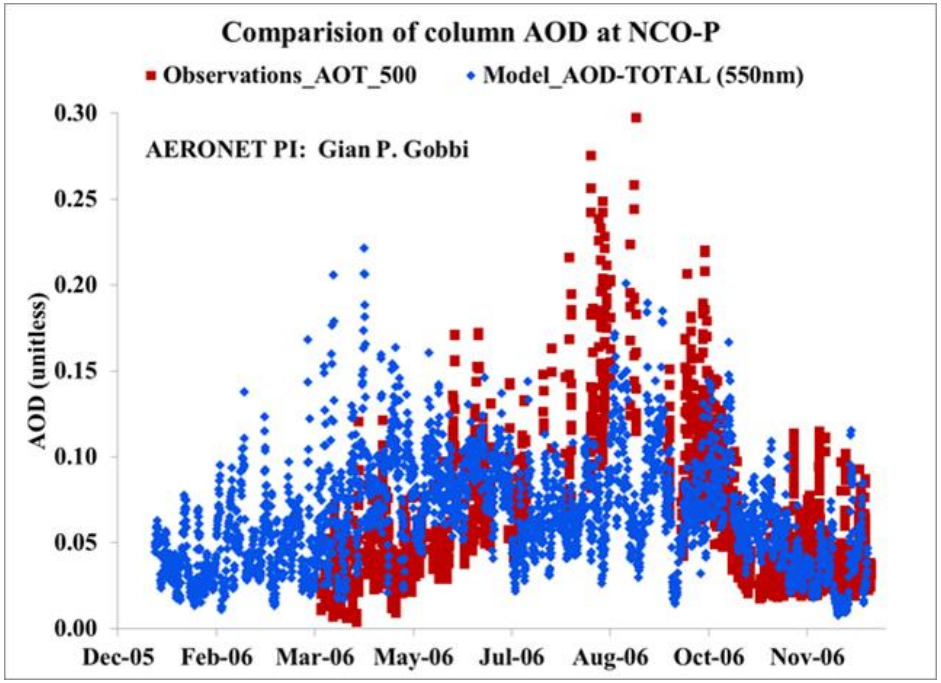
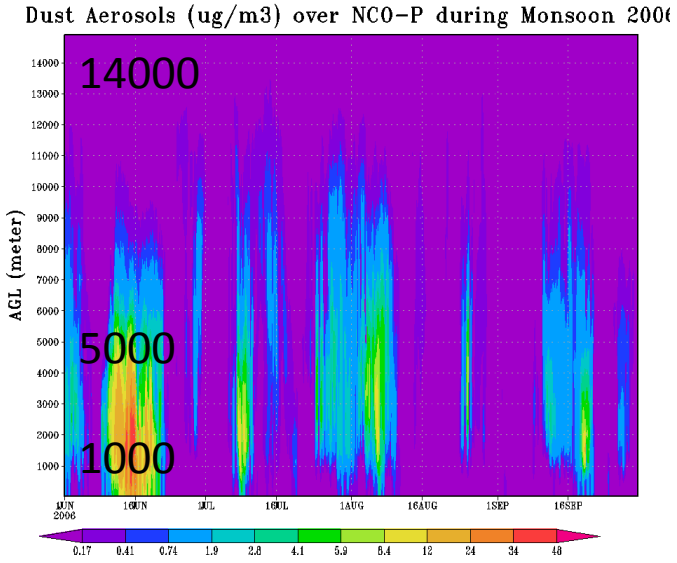
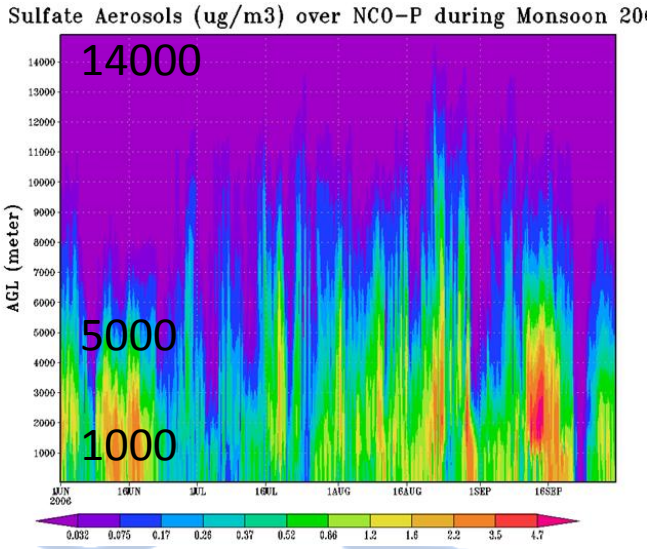
Aerosols Monsoon

Modeled Aerosols above Pyramid during Monsoon







Jun

Sep

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Urban Pollution: Kathmandu

- The "Sustainable Atmosphere for the Kathmandu Valley" (SusKat) project, implemented in collaboration with the international scientific community and local authorities, aims at creating a scientific basis for the design and implementation of air pollution mitigation options, including mitigations of Short-lived Climate-forcing Pollutants (SLCPs) in Nepal.
- In densely populated cities, like Kathmandu, the SLCFs compounds, together with other primary pollutants, are dangerous for human health, historical monuments, ecosystems, and for the regional climate.
- In the oldest part of Kathmandu city, Pakanajol, **continuous measurements** of O_3, BC, aerosol size distributions, PM10 and PM1, solar radiation and meteorological variables are carried out by Ev-K2-CNR and ISAC-CNR in collaboration with ICIMOD and IASS.
- **Preliminary results of these measurements show elevated levels of BC, particle number and O_3. Their variability appeared to be modulated by meteorological conditions, diurnal breezes and PBL and emissions.**
- **The Pakanjol "SusKat-ABC" station and the NCO-P Himalayan station provide two complementary perspective about the air pollution over South Asia and Nepal.**

ABC
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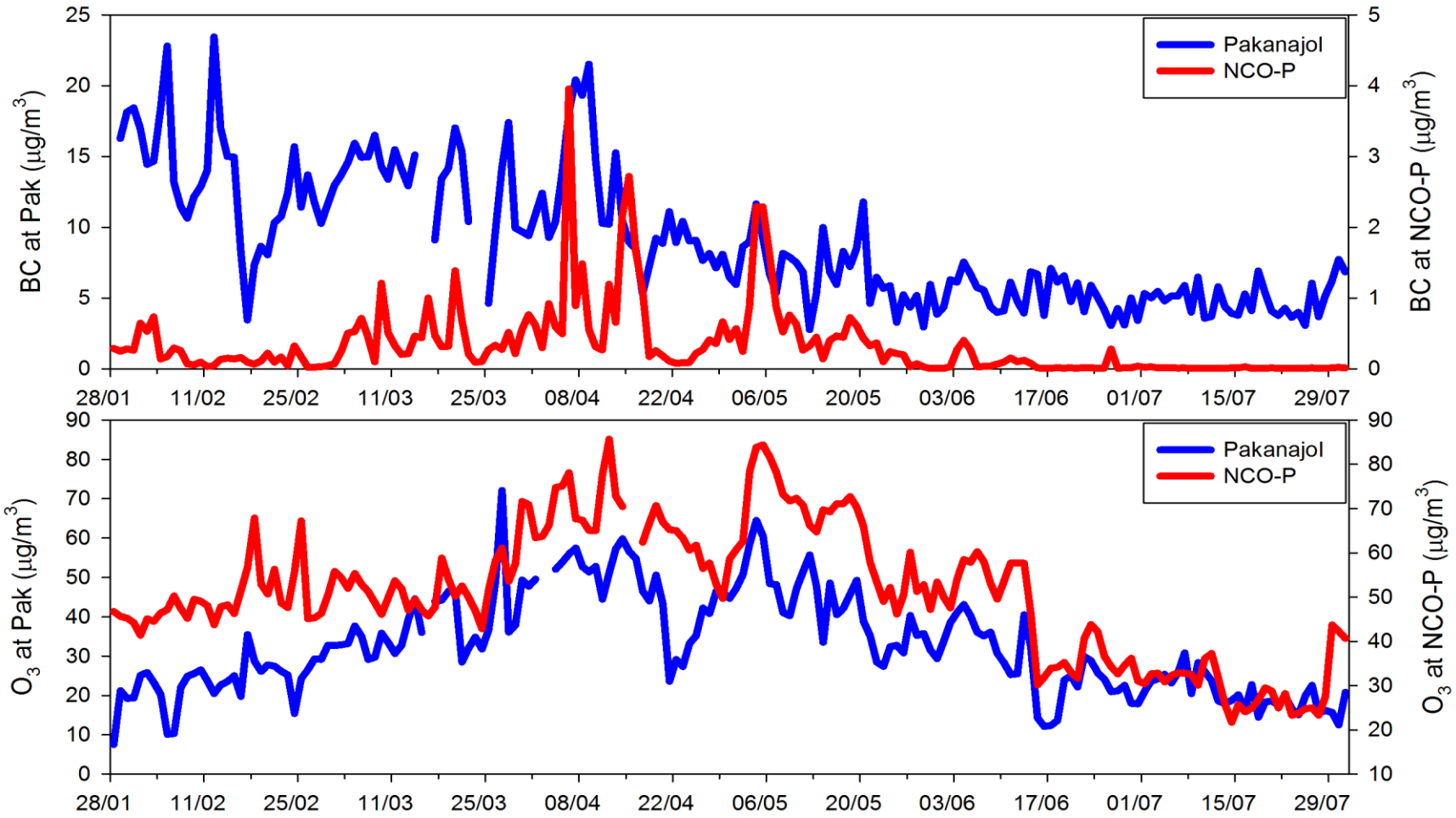
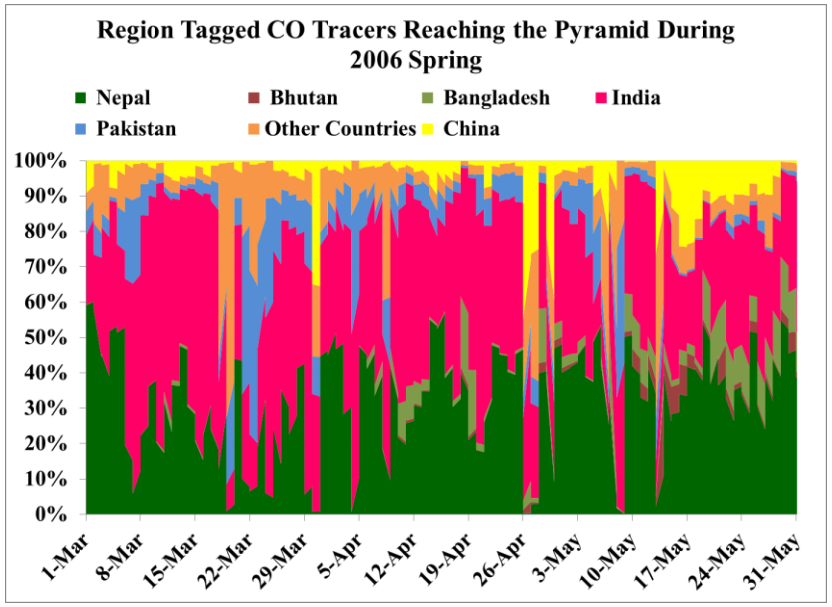
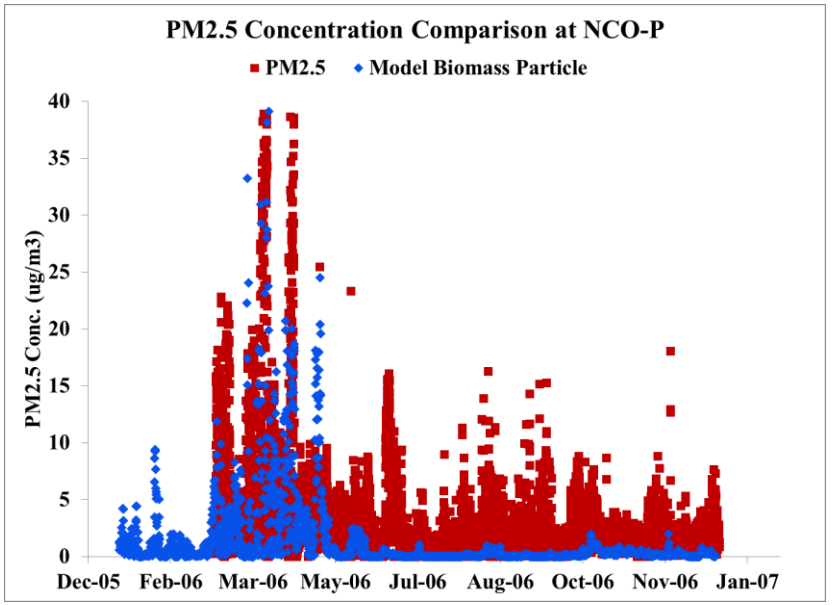
NextData
EvK2CNR
ISAC
ICIMOD 30
ASS POTSDAM

Preliminary Results: February-July 2013, Kathmandu versus Pyramid (Average Values)

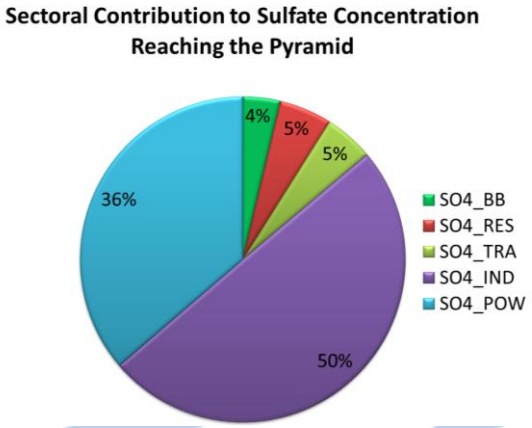


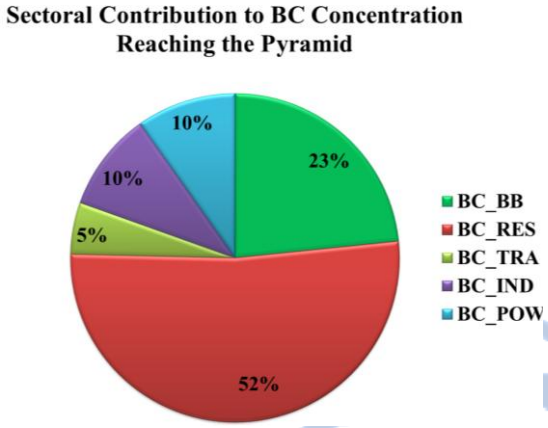
Regional and Sectoral Contribution

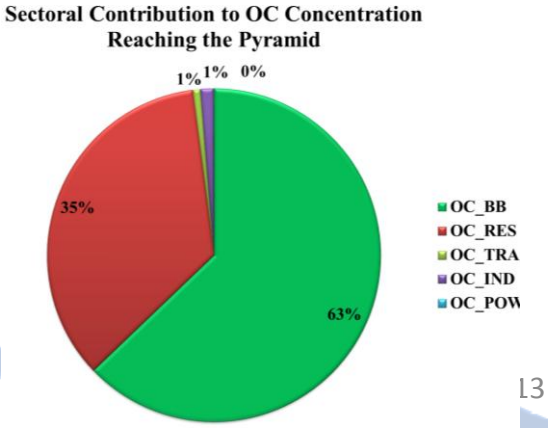




March April May 2006 Average Values







Thank You !!

Questions ??